PB-215 122

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Public Health Service
Cincinnati, Ohio

February 1946

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CINCINNATI 2, OHIO
FEBRUARY 1946.

A STUDY OF THE OPERATION OF THE MECHANICAL ACTIVATED SLUDGE PLANT AT THE ERIE PROVING GROUNDS LACARNE, OHIO

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INTRODUCTION

During the arrangements with the Army for the study of the mechanical aeration plant at Baer Field, Ind., the R. & U. Branch of the Engineer Corps Fifth Service Command also requested that a study of the plant at the Erie Proving Grounds be undertaken by the U. S. Public Health Service. Accordingly this plant was included in the plans for the study of the operation of small plants that was being made by this station. After a preliminary inspection of the plant and arrangements for the study were completed, the U. S. Public Health Service trailer laboratory was taken to the plant and the study was made from October 29 to November 8, 1945.

SEWAGE TREATMENT PLANT DESCRIPTION AND ENGINEERING DATA

This is a small activated sludge plant with mechanical aerators of the downdraft type.

The plant is located near the shore of Lake Erie between the warehouse-shop area and the firing range on the lake front. Although there were apparently very few troops quartered on the reservation and most of the personnel were civilian employees, the night rate of flow in g.p.m. (4 P.M.-8 A.M.) was nearly half the day rate. Sewage is pumped to the plant by two automatic ejector stations and, due to the intermittent operation of these pumping stations, reaches the plant in gushes which affect the flow through the entire plant. The sewage reaches the treatment plant at a rate of about 160 g.p.m. for about 15 minutes, followed by a 15-minute period of zero flow. Actual timing of one cycle of sewage flow on the afternoon of October 31 gave the following sequence of pump operation:

2:57 First pump on. Flow started

3:05 Second pump on. Flow increased.

3:06 First pump off. Flow decreased.

3:19 Second pump off. Flow stopped.

Sewage flow off 17 min.

3:36 First pump on.

3:38 Second pump on.

3:40 First pump off.

(Sewage flowing 22 minutes, off 17 minutes)

The incoming sewage passes through a hand-raked bar screen consisting of 3/8" bars on 1-7/8" centers before entering the primary settling tank.

The primary tank is rectangular in plan, 30 ft. long by 7 ft. wide, with an average water depth of 9.12 ft., and is equipped with American Well Works sludge collector mechanism. The floor slopes to the sludge hopper at the inlet end. The return run of the scrapers serves to skim the surface of the tank. Sludge is discharged at intervals to heated, covered digesters.

There are four aerator tanks, each 17 ft. square with a water depth of 10 ft., equipped with American Well Works downdraft aerators. The aerators were being operated intermittently, being controlled by time clocks on the individual aerator. The aerators were in operation 60% of the time, averaging 9 minutes on and 6 minutes off. Return activated sludge is added to the primary effluent just before it enters the two "primary" aerators. After entering the "primary" aerators, the mixed liquor passes through the four aerators in a rather indefinite manner as the stop planks between the various aerators were all removed. When the survey was started on October 29, one of the primary aerators was out of service due to electrical trouble and had been inoperative for several days. The incoming mixed liquor had been shut off, but the stop planks between the aerators had not been put in place and

the septic liquor pumped out. This aerator was returned to service late in the afternoon on October 30.

These are two final settling tanks operating in parallel. These tanks are 30 ft. long by 8 ft. wide, with an average water depth of 7.87 ft., and are equipped with American Well Works sludge collector mechanisms. The sludge hoppers are at the inlet ends and the rate of sludge removal is controlled by the hydraulic head through adjustable sleeve valves.

Although the plant had provisions for installation of a chlorinator, the effluent was not being chlorinated.

DESCRIPTION OF PLANT UNITS

Screen

Inclined bars, hand-raked. Bars are 3/8" wide on 1-7/8" centers.

Primary Settling Tank

Rectangular tank 30' x 7' x 9.12' average water depth, equipped with American Well Works sludge collector, the return run of the flights serving to skim the surface of the tank.

Capacity: 1,915 cu. ft., or 14,324 gal.

Weir length: 14 ft.

Aerators

Rectangular tanks 17' x 17' x 10' water depth. Four tanks equipped with American Well Works mechanical aerators (downdraft). Aerators are operated intermittently, controlled by individual time-clock switches. The mixed liquor flows directly into two of the tanks and then circulates in all four tanks in an indeterminate manner.

Capacity (4 tanks): 11,560 cu. ft., or 86,468 gal.

Final Settling Tanks - 2 tanks in parallel

Rectangular tanks 30' x 8' x 7.87' average water depth. Two tanks in parallel, equipped with American Well Works sludge collectors. Sludge hopper at inlet end. Each tank has 32 ft. of effluent weir.

Capacity (both tanks): 3,778 cu. ft., or 28,260 gal.

Weir length (both tanks): 64 lineal feet.

FLOW MEASUREMENT DEVICES & HYDRAULIC DATA

The only flow measurement device provided in the plant is a 90° V-notch weir on the final effluent for measuring the sewage flow. The weir is set in a concrete chamber about 4' x 6' and the head is transmitted through a short length of 1-1/2" pipe to a float chamber and recorded on a Bailey meter recorder equipped with a totalizer dial. The chart reading x 10 gives the rate of flow in gallons per minute and the totalizer reading x 720 indicates the total gallons.

No means was provided for measuring the rate of sludge return, but the operator stated that on the basis of rough measurements and pump capacity it was estimated to be about 125 g.p.m. A suppressed weir with a length of 1.43 ft. was installed in the sludge diversion box. This weir consisted of a shallow stop plank of sheet steel 1/4" thick with a square edge inserted in stop plank grooves across the box. There was a great deal of turbulence due to the nearby discharge from the centrifugal sludge return pumps, but it was felt that this weir would give at least a fair approximation of the sludge flow. This weir was read twice daily during the period of the survey after it was installed. The return sludge flow was very uniform as no adjustments were made of the sludge discharge valves from the settling tanks. The average observed head of 0.10 ft. indicates a sludge return rate of 74 g.p.m.

The observed flows and computed detention periods during the period of the survey are given in Tables 1 to 4.

COLLECTION OF SAMPLES

During the period spent at the Erie Proving Grounds, treatment plant samples were collected every other day for ten days. These five sets of samples were collected every half-hour from the raw and settled sewage and plant effluent, from 8:00 A.M. to 8:00 P.M. and composited according to flow. No adjustment was made for detention time in any of the various units of the plant. Samples were also collected daily from the mixed liquor influent and effluent ends of the aeration tanks and run for dissolved oxygen. These samples together with the samples used in the oxygen utilization tests were necessarily grab samples.

ANALYTICAL PROCEDURES

The analytical procedures used were those contained in "Standard Methods for Examination of Water and Sewage" except in the case of the dissolved oxygen determinations. This latter test made use of sodium azide[1] in the alkaline iodide reagent to prevent interference from nitrites. In the determination of dissolved oxygen in the mixed liquor the oxidation inhibitor of Ruchhoft and Placak [2] was used.

The oxygen utilization rates [3] were determined on the mixed liquor by means of an apparatus specially designed at this station. Since these were made chiefly for research purposes they are of no special significance in the operation of this plant.

ANALYTICAL RESULTS

In Tables 5, 6, and 7 are given the basic analytical results obtained for the raw sewage, primary and final effluents. The raw sewage shows an average B.O.D. of 164 p.p.m. which represents a weak sewage for a Military Post. The weakness of this particular sewage is also reflected in the suspended solids, free ammonia and Kjeldahl nitrogen results. The volatile matter in the raw sewage averages about 86%.

PRIMARY PLANT EFFICIENCY

Using the data presented in Tables 5, 6, and 7 the percentage removal of B.O.D. suspended solids, free ammonia and Kjeldahl nitrogen are calculated for primary and complete treatment and given in Table 8. It will be noted that there is practically no reduction in the free ammonia or Kjeldahl nitrogen in the primary treatment. The percentage removal of B.O.D. and suspended solids is 15.2 and 47.6 respectively. Considering the average detention time of 4.9 hours in the primary tank these removals are in the lower limits of normal operation.

OVERALL PLANT EFFICIENCY

The overall efficiency of the plant show percentage removals of B.O.D. and suspended solids to be 89.9 and 83.6 respectively. In Table 9 it will be noted that an average of 103.0 pounds of B.O.D. are applied to the aeration tanks per day. This is equivalent to 8.9 pounds of B.O.D. per 1000 cu. ft. of aeration tank capacity and is a decidedly small load. The calculated B.O.D. load per pound of suspended solids in the secondary units is .27 pound. At other army plants, bulking was indicated when the B.O.D. load exceeded .2 pound per pound of suspended solids. In Tablell it is shown that on an average

only about 540 p.p.m. of suspended solids is carried in the mixed liquor and 1050 in the return sludge. The calculated efficiency of the secondary treatment averaged 75 percent. The low solids content of the mixed liquor no doubt contributed to this lower efficiency of the secondary units. It is also noted that by concentrating the return sludge by cutting down its volume from about 150% to about 40% the solids are built up in the aeration tanks. However, it will also be seen that the solids content of the return sludge dropped to around 300 p.p.m. with a corresponding drop to about 140 p.p.m. in the aeration tanks. This was due to the fact that there was insufficient supervision and operation control of the plant. The sludge hoppers in the aeration tanks became plugged and very little sludge channeled through with the clarified liquor. In Table11 are also given the settleable solids, percent ash and sludge index of the mixed liquor. The ash content averaged about 14% which no doubt contributed to the rather poor settleability of the sludge with consequent high sludge index values ranging from 214 to 686.

DISSOLVED OXYGEN STUDIES

In Table 12 are given dissolved oxygen values as determined on the influent and effluent mixed liquor and also the plant effluent. As would be expected the dissolved oxygen content was higher in the morning than in the afternoon due to the increase in sewage strength during the day. The weak strength of the sewage is reflected in the average dissolved oxygen content of 2.33 p.p.m. at the influent end of the mixed liquor tanks. Approximately 1.0 p.p.m. increase in dissolved oxygen in the aeration tanks was found which is rather low for a sewage of this strength and an average aeration period of 11.7 hours. The average of 3.45 p.p.m. of dissolved oxygen in the mixed liquor effluent checks well with the average 3.39 p.p.m. found in the plant effluent.

OXYGEN UTILIZATION STUDIES

The oxygen utilization rates run on the mixed liquor with the special apparatus show not only a weak sewage but also a slow oxidizing sludge. The data is presented in Table 13. As would be expected, an increase in the rates occurred during the day as the sewage strength increased. However, it was found that in only one instance did the mixed liquor utilize any oxygen in the first 30 minutes of aeration and that occurred in a sample taken at 5:45 P.M. In all other cases from 45 - 90 minutes aeration period was required before oxygen utilization began.

SUMMARY

The sewage as received at this plant showed a B.O.D. of 164 p.p.m. and 162 p.p.m. of suspended solids. The primary treatment removed 15.2 and 47.6% of the B.O.D. and suspended solids with a detention time of 3.4 hours at maximum flow and 9.8 hours at minimum flow. Due to the weak sewage only 8.9 pounds of B.O.D. are applied per 1000 cu. ft. of aeration tank volume. This is considerably lower than standard loadings and probably one-half of the aeration capacity would be sufficient for this plant. The over-all plant efficiency was 89.9 percent removal for B.O.D. and 88.6 percent removal for suspended solids. It is concluded that the plant efficiency might have been improved by increasing the suspended solids content of the mixed liquor. This could only be accomplished, however, by more careful supervision of operation and control, than this plant was given. It must be concluded that this type of plant is not well suited for the treatment of the variation in sewage flow and the character of supervision and control provided at the Erie Proving Grounds.

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